Introduction

This study aims to explore the relationships between brain MRI results and the presence of dementia. Understanding these relationships can aid in early detection and treatment planning for individuals at risk of dementia. Specifically, we'll examine how MRI features, demographic data, and clinical assessments correlate with dementia status.

Research Questions

1. How do Estimated Total Intracranial Volume (eTIV) differ between demented and nondemented groups?
2. How do Normalize Whole Brain Volume (nWBV) differ between demented and nondemented groups?
3. How do Atlas Scaling Factor (ASF)) differ between demented and nondemented groups?

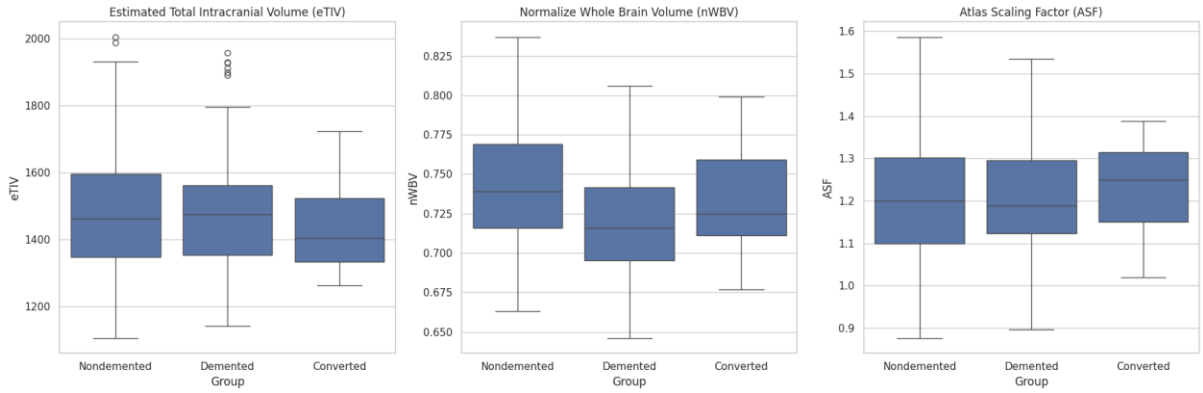
Data Cleaning

The raw dataset has a total of 15 columns and 294 rows. Below we outlined our data and its' dictionary of what each column means.

Subject ID	Identification
MRI ID	MRI Identification
Group	Demented/Nondemented
Visit	Visit Times
MR Delay	Delay
M/F	Gender
Hand	Dominant Hand
Age	Age in Years
EDUC	Education Level
SES	Socioeconomic Status
MMSE	Mini Mental State Examination
CDR	Clinical Dementia Rating
eTIV	Estimated Total Intracranial Volume
nWBV	Normalize Whole Brain Volume
ASF	Atlas Scaling Factor

Exploratory Data Analysis

For the EDA, we'll focus on the following analyses aligned with our research questions: comparison of MRI-derived measures (eTIV, nWBV, ASF) between demented and nondemented groups. This will involve generating summary statistics and visualizations such as box plots or histograms to compare these measures across groups.



The box plots presented above offer a comparative analysis of MRI-derived measures—eTIV, nWBV, and ASF — between demented and nondemented groups, revealing distinct patterns. The eTIV illustrates a slight variation between the groups, though the differences are not significantly pronounced, with both groups displaying a comparable range of eTIV values. In contrast, the nWBV exhibits a noticeable difference, where the nondemented group generally has higher nWBV values, suggesting that a decrease in whole brain volume may be linked to dementia. Similarly, the ASF, which inversely relates to eTIV as it is a scaling factor, shows lower values in the demented group. This correlates with the trends observed in nWBV, indicating brain atrophy associated with dementia. These observations collectively provide insights into the structural changes in the brain that may accompany the onset and progression of dementia.

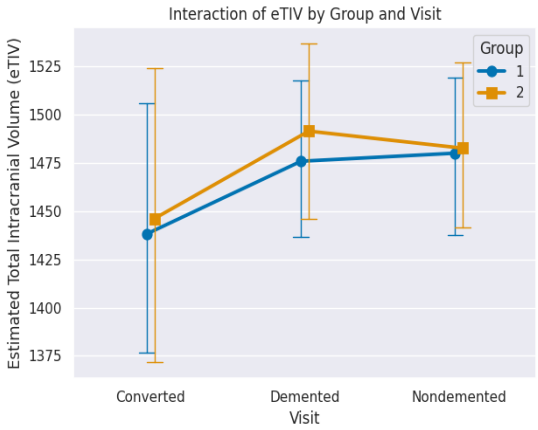
Mixed Effect ANOVA

For the mixed-effects ANOVA, we'll consider "Group" (demented vs. nondemented) as the fixed effect and "Subject ID" as the random effect to account for intra-subject variability across multiple visits. We'll focus on eTIV, nWBV, and ASF as dependent variables.

Mix Effect ANOVA for Estimated Total Intracranial Volume (eTIV):

	Source	SS	DF1	DF2	MS	F	p-unc	Np2	eps
0	Group	37424.71	2	141	18712.35	0.30	0.74	0.0042	NaN
1	Visit	5573.92	1	141	5573.92	9.22	0.0028	0.061	1.0
2	interaction	1004.78	2	141	502.39	0.83	0.44	0.012	NaN

For group effect, there is no statistically significant difference in eTIV between the demented and nondemented groups ($p > 0.05$). For visit effect, there is also no significant difference in eTIV across visits ($p > 0.05$). For group*visit interaction, we see no significant interaction effect between group and visit on eTIV ($p > 0.05$).



Now let's check the assumptions:

Sphericity: p-value = 1 > 0.05, sphericity is met.

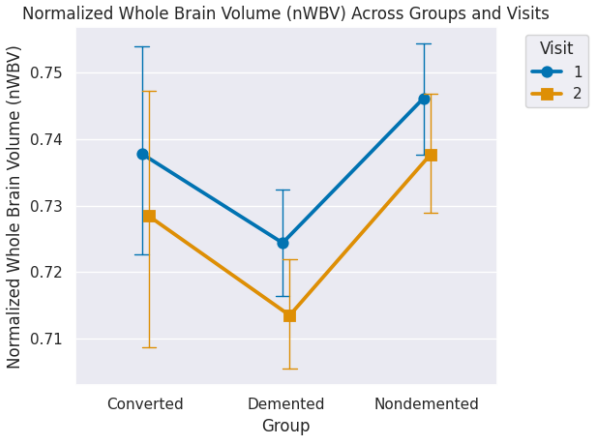
Normality: p-value for all combination > 0.05, normality is met

Homogeneity: p-value > 0.05 for both case, homogeneity is met.

Mix Effect ANOVA for Normalize Whole Brain Volume (nWBV):

	Source	SS	DF1	DF2	MS	F	p-unc	Np2	eps
0	Group	0.034	2	141	0.017	6.71	1.64e-03	0.087	NaN
1	Visit	0.0065	1	141	0.0065	94.25	2.23e-17	0.40	1.0
2	interaction	0.00021	2	141	0.00011	1.53	2.19e-01	0.021	NaN

For group effect, there is a statistically significant difference in nWBV between the demented and nondemented groups ($p < 0.05$), with the effect size (η^2) being quite substantial, which indicates a meaningful difference. For visit effect, there is a significant difference in nWBV across visits ($p < 0.001$), suggesting changes in nWBV over time within subjects. For the group and visit interaction, there is no significant interaction between group and visit on nWBV ($p > 0.05$), implying that the rate of change over visits does not significantly differ between the demented and nondemented groups.



Now let's check the assumptions:

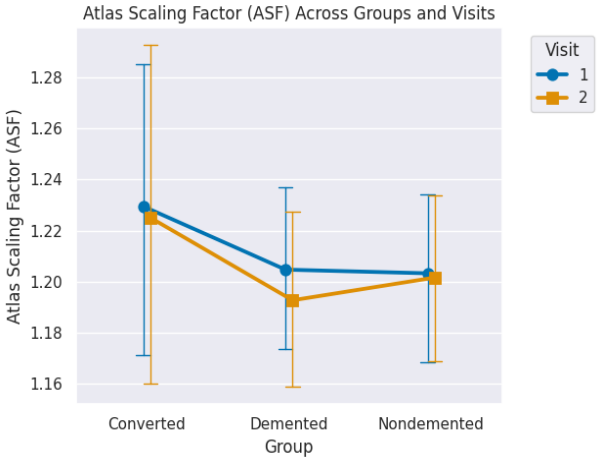
Sphericity: p-value = 1 > 0.05, sphericity is met.

Normality: p-value for all combination > 0.05, normality is met

Homogeneity: p-value > 0.05 for both case, homogeneity is met.

Mix Effect ANOVA for Atlas Scaling Factor (ASF):

	Source	SS	DF1	DF2	MS	F	p-unc	Np2	eps
0	Group	0.018	2	141	0.0092	0.23	0.79	0.0033	NaN
1	Visit	0.0032	1	141	0.0032	8.75	0.0036	0.058	1.0
2	interaction	0.00074	2	141	0.00037	1.03	0.36	0.014	NaN



For group effect, there is no significant difference in ASF between the demented and nondemented groups ($p > 0.05$). For the visit effect, there is a significant difference in ASF across visits ($p < 0.05$), indicating changes over time. For the group and visit interaction, there is no significant interaction effect between group and visit on ASF ($p > 0.05$).

Now let's check the assumptions:

Sphericity: p-value = 1 > 0.05, sphericity is met.

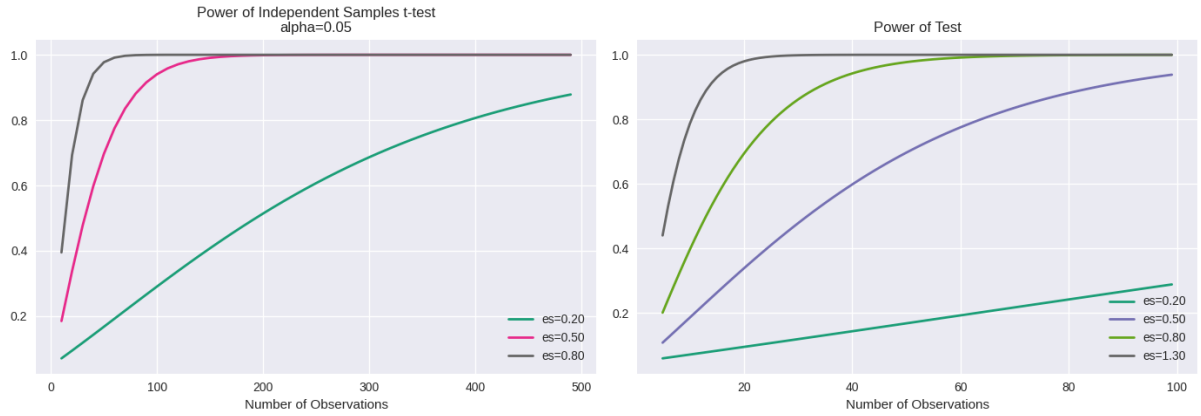
Normality: p-value for all combination > 0.05, normality is met

Homogeneity: p-value > 0.05 for both case, homogeneity is met.

Statistical Power Analysis

Given power = 0.91, alpha = 0.05, effect size = 0.7, we compute the required sample size to be 45.45, rounds up is 46.

The following is to compare the impact of varying effect sizes and sample sizes on the power of the t-test.



Conclusion

In summarizing the outcomes of the research questions concerned with the comparison of brain volume metrics between demented and nondemented groups, the findings indicate a multifaceted picture. For the first research question focusing on Estimated Total Intracranial Volume (eTIV), it is observed that the time at which the visit occurs plays a significant role in the readings obtained for this metric. It is found that, irrespective of whether an individual is categorized within the demented or nondemented group, the timing of the assessment has a notable impact on the eTIV measurements.

Delving into the second research question that assesses the Normalized Whole Brain Volume (nWBV), a similar trend emerges. The results underscore that the point in time when the scan is performed holds considerable weight in the evaluation of nWBV figures. This temporal influence seems to override any substantial effect that the classification of dementia status might exert on the nWBV.

In addressing the third research question related to the Atlas Scaling Factor (ASF), the conclusion aligns with the observations made for the other two brain metrics. Here too, the temporal factor — the specific juncture of the visit — is of significant consequence. ASF readings are seen to be more sensitive to when the assessment takes place rather than to whether the subjects belong to the demented or nondemented group.

Expanding upon the collective insights from all three research inquiries, it becomes evident that the metrics of eTIV, nWBV, and ASF are all subject to temporal effects. The distinction between demented and nondemented groups, as well as the potential interplay between group identity and the timing of visits, appears to be of minimal significance in explaining the variances in these brain volume measurements. Therefore, while it is clear that the timing of assessments is critical in the accurate quantification of brain metrics, the same cannot be said for the presence of dementia when considered alongside the factor of time.